

REMARKS

In view of the following remarks, reconsideration and allowance are respectfully requested.

Claims 1-14, 32-33 are pending, with Claims 1, 9 and 32 being independent. Claims 1-14, 32-33 were elected without traverse in response to a restriction requirement. No new matter has been added.

Claims 2, 6, 9-10, 13 stand rejected under 35 U.S.C. 112 for allegedly being indefinite. Claim 1 stands rejected under 35 U.S.C. 102(b) as allegedly being anticipated by U.S. Patent No. 6433427 to Wu et al. ("Wu"). Claims 1-2, 4-5, 8 stand rejected under 35 U.S.C. 102(e) as allegedly being anticipated by U.S. Patent Pub. 2003/0025202 to Mikagi et al. ("Mikagi"). Claims 3, 9-13 stand rejected under 35 U.S.C. 103(a) as allegedly being unpatentable over Mikagi in view of U.S. Patent No. 6285083 to Imai et al. ("Imai"). Claim 7 stands rejected under 35 U.S.C. 103(a) as allegedly being unpatentable over Mikagi in view of U.S. Patent No. 6614590 to Tatch. Claims 32-33 stand rejected under 35 U.S.C. 103(a) as allegedly being unpatentable over Mikagi in view of U.S. Patent No. 6639315 to Kazama et al. ("Kazama"). Claim 6 stands rejected under 35 U.S.C. 103(a) as allegedly being unpatentable over Mikagi in view of U.S. Patent No. 6528409 to Lopatin et al. ("Lopatin"). Claim 14 stands rejected under 35 U.S.C. 103(a) as allegedly being unpatentable over Mikagi and Imai in view of Lopatin and Tatch.

Claim Rejections 35 U.S.C. 112 - Claims 2, 6, 9-10, and 13
Claims 2 and 10

The 35 U.S.C. 112 rejection to Claims 2 and 10 should be removed because those claims particularly point out claimed

Amendments to the Drawings:

The attached replacement sheets of drawings include the formal drawings for previously-filed Figs. 1A-1D, 2-8. No changes have been made with respect to the figures and the respective figure numbers in the drawings.

subject matter. For instance, Claims 2 and 10 claim that the diffusion barrier is an electroless diffusion barrier. Electroless diffusion barriers are fully described in the disclosure (See, for example, page 5, lines 28-31; page 7, lines 13-14, 24-25; page 8, lines 10-11, 25-26, 29-30; page 9 lines 1-4). Furthermore the disclosure further describes and points out electroless diffusion barriers and deposits on page 5, lines 26-31 and page 6, lines 1-13:'

A diffusion barrier layer 225 can be selectively positioned on top of the base layer metal 230. Selective deposition may mean that some surfaces may have another layer deposited only on a portion of that surface. The electroless diffusion barrier can prevent Cu and Sn from diffusing through the diffusion barrier. The diffusion barrier layer 225 may be electroless and located in a position to prevent the intermixing of Cu from the base layer metal 230 and Sn from the bump layer 215 or solder layer 210. The diffusion barrier layer 225 may prevent CuSn intermetallic formation and whisker formation. The diffusion barrier layer 225 may prevent bump delamination and improve the processing yield of fabricating die package interconnects. The diffusion barrier layer 225 may include, among others, any one of CoBP, CoWP, CoWB, CoWBP, NiBP, NiWP, NiWB, and NiWBP.

Electroless deposits may offer one or more advantages when deposited on irregularly shaped objects, patterns, and recesses. In electroless plating, electrons are supplied by a chemical reducing agent. In general, electroless plating

may refer to a reduction of metal ions from a solution containing a reducing agent. The reducing agent can supply electrons by oxidation on a catalytic surface. Electroless deposits may have high uniformity and little to no compressive stress during plating. Electroless deposits tend to be uniform in thickness over all of the shape of the underlying structure, therefore providing more uniform current densities and reducing some electromigration issues. Electroless barriers may also offer the advantages of being low cost, selective, and amorphous.

Therefore, the Applicants respectfully request allowance of Claim 2 and 10.

Claim 6

Claim 6 recites that the Sn alloy comprises "one of 0.7Cu, Bi, Sb, and 3.5Ag", which is fully described in the disclosure. In one exemplary implementation, the disclosure describes that the "electroplating of Sn may include Sn and the alloys of Sn, such as 0.7Cu, Bi, Sb, and 3.5Ag" (page 6, lines 29-30). In another exemplary implementation, the disclosure states that some "alloys of Sn may include any one of 0.7Cu, Bi, Sb, and 3.5Ag" (page 7, line 17). Therefore, the 35 U.S.C. 112 rejection to Claim 6 should be withdrawn because Claim 6 particularly points out claimed subject matter, and that subject matter is fully described in the disclosure.

Claim 9

Claim 9 has been amended to particularly point out that the bump is distinctly being claimed. Furthermore, the figures have been amended and are currently being submitted as formal drawings to show the bump. For example, Figure 2 shows the bump

215 (which finds support at disclosure page 6, lines 21-22), Figure 4 shows the bump 415 (which finds support at page 7, lines 22-31), and Figure 6 shows the bump 615 (which finds support at page 8, lines 23-31). No new matter has been added. For at least these reasons, the Applicants respectfully ask the rejection to Claim 9 be withdrawn.

Claim 13

Claim 13 has been amended to be in independent form to recite the solder layer being on top of the wetting layer. No new matter has been added, and the subject matter for Claim 13 is shown in Fig. 6 and recited in the disclosure on page 8, lines 23-31; and page 9, lines 1-7. Because Claim 13 particularly points out and claims the subject matter, Claim 13 should be placed in condition for allowance.

35 U.S.C. 102 Rejections to Claims 1-2, 4-5, 8

Claim 1 is patentable over Wu at least because Wu fails to describe each and every feature of the claim as recited in the claim. For example, Wu describes a wafer level package with dual stress buffer layers for I/O redistribution and a method for fabricating a wafer level package. However, Wu fails to anticipate having a diffusion barrier as recited in Claim 1 to prevent Cu and Sn from diffusing through the diffusion barrier and to prevent CuSn intermetallic formation in the apparatus. The undesired CuSn intermetallic formation is shown in Figures 1A-1D of the disclosure.

Wu cannot prevent CuSn intermetallic formation because Wu recites that the wetting layer 28 is "normally formed of a Cu layer or a Ni layer" (Wu, Col. 2, lines 7-9). Because the structure in Wu shows that the solder 40 is in direct contact with the wetting layer 28 (Wu, Figures 1A-1F), the structure in Wu does not prevent CuSn intermetallic formation in the

structure as taught in Claim 1. Wu does not use a diffusion layer to separate the solder layer from a layer that includes Cu to prevent CuSn intermetallic formation as recited in Claim 1. For this reason alone, Claim 1 is patentable over Wu. The Applicants respectfully request allowance of Claim 1 and the removal of the 35 U.S.C. 102 rejection.

Claims 2, 4-5, and 8

Claims 2, 4-5, and 8 are allowable at least because they all depend on an allowable independent claim, Claim 1. Claims 2, 4-5, and 8 are further patentable because they recite allowable subject matter in their own right.

In one example, Mikagi does not anticipate preventing CuSn intermetallic formation using the diffusion barrier as recited in the base claim, Claim 1. Mikagi mentions that the diffusion barrier can prevent Sn from diffusing into the underlying wiring pad (Mikagi, paragraph 005). However, Mikagi fails to anticipate that Cu can diffuse through the diffusion barrier. Mikagi also fails to anticipate CuSn intermetallic formation because Mikagi teaches that the solder ball 20 is formed by a plating technique on a solder-wetting Cu film formed on the plating Ni film 54 (Mikagi, paragraph 0010). Mikagi teaches that the solder ball is formed of Sn (Mikagi, paragraph 0005). Because Mikagi places the solder ball formed of Sn in direct contact with the Cu solder-wetting film, Mikgai does not prevent CuSn intermetallic formation in the structure with a diffusion barrier (e.g., Claim 8 recites "wherein the diffusion barrier is further configured to reduce electromigration related to CuSn intermetallic formation"). Therefore, the Applicants contend that Claims 2, 4-5, and 8 are all allowable over Mikagi.

35 U.S.C. Rejections - Claims 3, 6, 7, 9-13, 14, 32-33

Claims 3, 10-13 are allowable at least because they each depend on an allowable independent claim, Claim 1 or Claim 9. As described above, Claim 1 recites patentable subject matter that is neither taught nor suggested in Mikagi. Claim 9 recites subject matter similar to Claim 1. In one example, neither Imai nor Mikagi, alone or in combination, teaches or suggests preventing CuSn intermetallic formation using the diffusion barrier as recited in the base claim, Claim 1 or Claim 9. For example, Imai teaches that the bump 16 is made of Cu or Ni (Imai, Col. 3, lines 16-18), and the solder 20 in contact with the bump is made of a Sn alloy (Col 4, lines 56-67, Col, 5, lines 1-8). Claims 3, 10-13 are further patentable because they recite allowable subject matter in their own right. Therefore, Claims 3, 9-13 should be placed in condition for allowance.

Claim 7 is patentable over Mikagi and Tatch, alone or in combination, at least because the cited references do not teach a diffusion barrier to prevent the mixing of Sn and Cu between layers and the formation of intermetallic CuSn. Tatch describes an optical semiconductor hermetic sealing package with one or more plates (Tatch, Abstract). Tatch describes that a bottom plate is made of "Cu or Fe-Ni-Co alloy or Fe-Ni alloy" and that the Cu bottom plate can be plated beforehand with "Ni or NiB" (Tatch, Col. 7, lines 19-21, Col. 6, lines 54-60). In particular, Tatch teaches that pure Cu is preferable because its Young's modulus is small (Tatch, Col. 6, lines 54-60). The office action is asserting that the wetting layer is the "Ni or NiB" plating (page 7 of office action). However, such a construction would destroy an intended function recited in Claim 1. For example, if the wetting layer is the "Ni or NiB" plating, then the Cu bottom plate in Tatch would have to be the underlying diffusion barrier. However, the diffusion barrier in

Claim 1 is not made from Cu, and furthermore, the diffusion barrier in Claim 1 could not be made from Cu if it is configured to prevent Cu and Sn from diffusing through the barrier and to prevent the intermetallic formation of CuSn in the apparatus. Therefore, the 35 U.S.C. 103 rejection to Claim 7 should be respectfully withdrawn for at least these reasons.

Claims 32-33 are patentable because Kazama fails to remedy the deficiencies of Mikagi. Kazama teaches a circuit board, but fails to teach or suggest a diffusion barrier to prevent the intermetallic formation of CuSn in a die package interconnect. Accordingly, Claims 32-33 should be placed in condition for allowance.

Claims 6 and 14 are allowable because Lopatin fails to remedy the deficiencies of Mikagi, Kazama, and Imai. For example, Lopatin teaches using a diffusion barrier between a copper layer and an insulating layer made of a dielectric, such as Silicon Dioxide or Silicon Nitride (Col. 1, lines 40-55). Lopatin also teaches that a layer of Cu can directly contact a layer of Sn (Lopatin, Fig. 10). For example, Fig. 10 of Lopatin shows that the conductive fill material 230 is in contact with an activation layer 232 (Col. 8, lines 66-67; Col. 9, lines 1-5). The conductive fill material 230 is copper (Col. 7, line 65; Col. 8, lines 1-6). Therefore, the structure of Lopatin doesn't teach a diffusion barrier to prevent the formation of an intermetallic CuSn layer, but instead teaches that "the diffusion barrier material 228 ... prevents diffusion of copper from the conductive fill material 230 into the surrounding insulating materials 109 and/or 222". The insulating materials are made of a dielectric, such as Silicon Dioxide or Silicon Nitride (Col. 1, lines 40-55), and not Sn. For at least these reasons, Claim 6 is allowable over the cited references, and the 35 U.S.C. 103 rejection should be respectfully withdrawn.

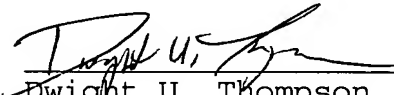
CONCLUSION

In view of the amendments and remarks, the Applicants believe that all pending claims, Claims 1-14, 32-33 are in condition for allowance and ask that those pending claims be allowed. The foregoing comments made with respect to the positions taken by the Examiner are not to be construed as acquiescence by the Applicants with other positions of the Examiner that have not been explicitly contested. Accordingly, Applicants' arguments for patentability of a claim should not be construed as implying that there are not other valid reasons for patentability of that claim or other claims.

No fee is believed to be currently due. Please apply any charges not covered or credits to Deposit Account No. 06-1050.

Respectfully submitted,

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